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Module 7: Best Management Practices

Non-Structural Best Management Practices

- Direct growth to identified areas;
- Protect sensitive aquatic resources;
- Establish buffers along stream and other waters;
- Maintain existing runoff patterns and Tc;
- Minimize impervious surfaces;
- Minimize disturbance of soils and vegetation;
- Encourage infill and re-development;
- Educate on material disposal/recycling
- Spill Prevention/Clean Up
- Identify and eliminate illicit discharges
- Promote street sweeping
- Develop Public Education/Participation programs

Non-Proprietary Clearinghouse BMPs

1. **Impervious Disconnection**
2. **Sheet flow to Conservation Area/Filter Strip**
3. **Grass Channels**
4. **Soils Compost Amendments**
5. Vegetated Roofs
6. Rainwater Harvesting
7. Permeable Pavement
8. Infiltration
9. Bioretention (including Urban Bioretention)
10. Dry Swales
11. Wet Swales
12. Filtering Practices
13. Constructed Wetlands
14. Wet Ponds
15. Dry Extended Detention Ponds

Site Design BMPs



BMP Design Specifications

- All BMP Design Specifications can be found at:
<http://vwrrc.vt.edu/swc/NonPBMPSpecsMarch11>
- 2011 version referenced in regulations with some minor corrections (no one would want the maximum soil depth for Bioretention set at 48 feet!) and updates
- No changes were made to performance credits or critical sizing methods



BMP Design Specifications

- Changes in design tables reflecting spreadsheet logic:
 - Definition of the design treatment volume as: " $Tv_{BMP} = [(1)(Rv)(A) / 12] + \text{any remaining volume from upstream BMP(s)}$ " in the treatment train;
 - Rather than " $Tv_{BMP} = [(1)(Rv)(A) / 12] - \text{the volume reduced by the upstream BMP(s)}$ "
- Changes to improve graphics, clarification in response to questions and comments
- General review and fix of inconsistencies

Rooftop/Impervious Area Disconnection

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 1



Rooftop/Impervious Area Disconnection

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 1

Summary of Stormwater Functions ¹



FUNCTION PROVIDED BY SIMPLE ROOFTOP DISCONNECTION	HSG SOILS A and B	HSG SOILS C and D
Annual Runoff Volume Reduction (RR)	50%	25%
Total Phosphorus (TP) EMC Reduction by BMP Treatment Process	0	0
Total Phosphorus (TP) Mass Load Removal	50%	25%
Total Nitrogen (TN) EMC Reduction by BMP Treatment Process	0	0
Total Nitrogen (TN) Mass Load Removal	50%	25%
Channel & Flood Protection	Partial: Designers can use the VRRM Compliance spreadsheet to adjust curve number for each design storm for the contributing drainage area (CDA), based on annual runoff reduction achieved	

NOTE: Stormwater functions of disconnection can be boosted if an acceptable alternate runoff reduction practice is employed. Acceptable practices and their associated runoff reduction rates are listed below. Designers should consult the applicable specification number for design standards.

Alternate Practice	Specification No.	Runoff Reduction Rate
Soil compost-amended filter path	4	50% ²
Dry well or french drain #1 (Micro-infiltration #1)	8	50%
Dry well or french drain #2 (Micro-infiltration #2)	8	90%
Rain garden #1, front yard bioretention (Micro-bioretention #1)	9	40%
Rain garden #2, front yard bioretention (Micro-bioretention #2)	9	80%
Rainwater harvesting	6	Defined by user
Stormwater Planter (Urban Bioretention)	9 (Appendix A)	40%

¹ CWP and CSN (2008), CWP (2007)

² Compost amendments are not credited with additional volume reduction on HSG A & B soils. Primary use is to improve the volume reduction performance of disconnection in C & D soils.

Rooftop/Impervious Area Disconnection

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 1

Simple Rooftop Disconnection Design Criteria

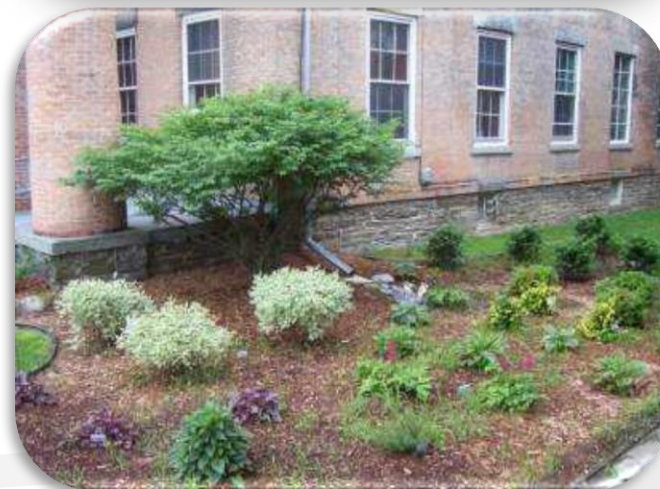
DESIGN FACTOR	SIMPLE DISCONNECTION
Maximum impervious (Rooftop) Area Treated	1,000 sq. ft. per disconnection
Longest flow path (roof/gutter)	75 feet
Disconnection Length	Equal to longest flow path, but no less than 40 feet ²
Disconnection slope	< 2%, or < 5% with turf reinforcement ³
Distance from buildings or foundations	Extend downspouts 5 ft. ⁴ (15 ft. in karst areas) away from building <i>if grade is less than 1%.</i>
Type of Pretreatment	External (leaf screens, etc)

¹ For alternative runoff reduction practices, see the applicable specification for design criteria. See Table 1 in this specification for eligible practices and associated specification numbers.

² An alternative runoff reduction practice must be used when the disconnection length is less than 40 feet.

³ Turf reinforcement may include EC-2, EC-3, or other appropriate reinforcing materials that are confirmed by the designer to be non-erosive for the specific characteristics and flow rates anticipated at each individual application, and acceptable to the plan approving authority.

⁴ Note that the downspout extension of 5 feet is intended for simple foundations. The use of a dry well or french drain adjacent to an in-ground basement or finished floor area should be carefully designed and coordinated with the design of the structure's water-proofing system (foundation drains, etc.), or avoided altogether.



Rooftop/Impervious Area Disconnection

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 1

Key Design Consideration: Application of a maximum impervious area per disconnection requires that larger sites (commercial or mixed use property) use Vegetated Filter Strips;



Rooftop/Impervious Area Disconnection

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 1

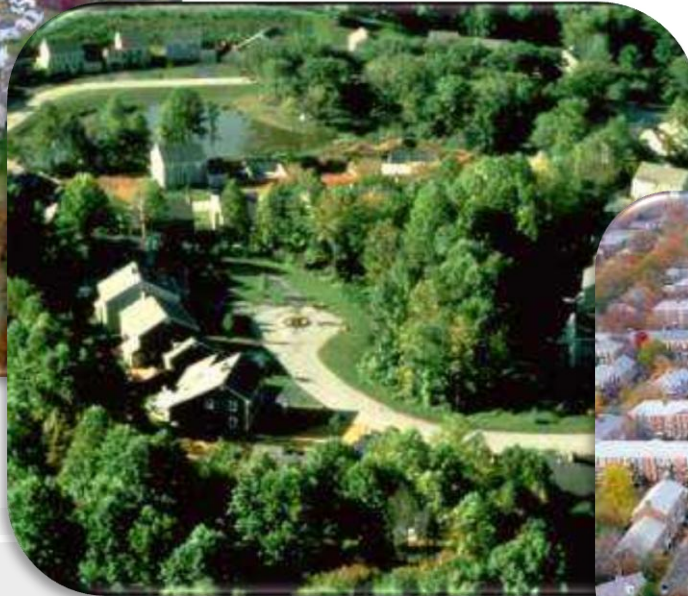
Key Design Consideration: Level spreader for concentrated flow (level spreader length should equal width of disconnection area)



Rooftop/Impervious Area Disconnection

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 1

Key Design Consideration: Recommend minimum lot sizes (e.g. 6,000 ft²) or go to alternative practices



Rooftop/Impervious Area Disconnection

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 1

Alternate Disconnection: Utilize where space required for simple disconnection may not be available, or enhanced performance is desired or required:

- Amended Soil Flowpath
- Micro-Bioretention (Raingardens)
- Rainwater Harvesting & Cisterns;
- Micro-Infiltration (dry wells);
- Urban Planter

Performance Credit for Alternate Disconnection
Practices are assigned according to micro-scale
criteria for practice



Rooftop/Impervious Area Disconnection

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 1

Alternate Disconnection:

- Rainwater Harvesting & Cisterns
- Micro-Infiltration (dry wells)
- Rain Gardens Urban Planter



Sheet Flow to a Vegetated Filter Strip or Conserved Open Space

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 2



Sheet Flow to a Vegetated Filter Strip or Conserved Open Space

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 2

Summary of Stormwater Functions ¹



Stormwater Function	Conservation Area		Vegetated Filter Strip	
	<u>HSG Soils</u> A and B	<u>HSG Soils</u> C and D	<u>HSG Soils</u> A	<u>HSG Soils</u> B ⁴ , C and D
	Assume no CA ² in Conservation Area		No CA ³	With CA ²
Annual Runoff Vol. Reduction (RR)	75%	50%	50%	50%
Total Phosphorus (TP) EMC Reduction ⁵ by BMP Treatment Process	0		0	
Total Phosphorus (TP) Mass Load Removal	75%	50%	50%	50%
Total Nitrogen (TN) EMC Reduction by BMP Treatment Process	0		0	
Total Nitrogen (TN) Mass Load Removal	75%	50%	50%	50%
Channel Protection and Flood Mitigation	Partial. Designers can use the <u>VRRM</u> Compliance spreadsheet to adjust curve number for each design storm for the contributing drainage area; and designers can account for a lengthened Time-of-Concentration flow path in computing peak discharge.			

¹ CWP and CSN (2008); CWP (2007)
² CA = Compost Amended Soils (see Design Specification No. 4)
³ Compost amendments are generally not applicable for undisturbed A soils, although it may be advisable to incorporate them on mass-graded A or B soils and/or filter strips on B soils, in order to maintain runoff reduction rates.
⁴ The plan approving authority may waive the requirement for compost amended soils for filter strips on B soils under certain conditions (see Section 6.2 below)
⁵ There is insufficient monitoring data to assign a nutrient removal rate for filter strips at this time.

Sheet Flow to a Vegetated Filter Strip or Conserved Open Space

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 2

Filter Strip & Open Space Design Criteria



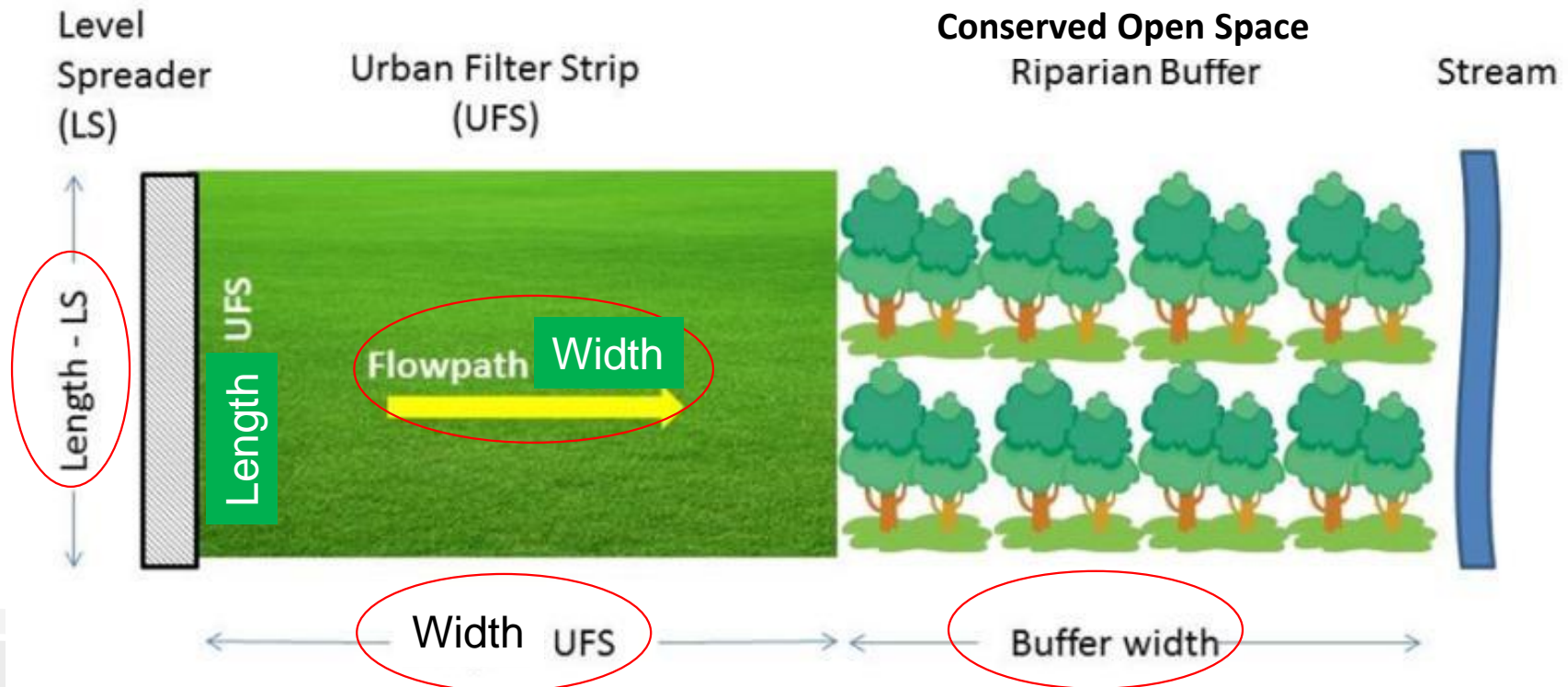
Design Issue	Conserved Open Space	Vegetated Filter Strip
Soil and Vegetative Cover (Sections 6.1 and 6.2)	Undisturbed soils and native vegetation	Amended soils and dense turf cover or landscaped with herbaceous cover, shrubs, and trees
Overall Slope and Width (perpendicular to the flow) (Section 5)	0.5% to 3% Slope – Minimum 35 ft width 3% to 6% Slope – Minimum 50 ft width The first 10 ft. of filter must be 2% or less in all cases ²	1% ¹ to 4% Slope – Minimum 35 ft. width 4% to 6% Slope – Minimum 50 ft. width 6% to 8% Slope – Minimum 65 ft. width The first 10 ft. of filter must be 2% or less in all cases
Sheet Flow (Section 5)	Maximum flow length of 150 ft. from adjacent pervious areas; Maximum flow length of 75 ft. from adjacent impervious areas	
Concentrated Flow (Section 6.3)	Length of ELS ⁶ Lip = 13 lin. ft. per each 1 cfs of inflow if area has 90% Cover ³ Length = 40 lin. ft. per 1 cfs for forested or re-forested Areas ⁴ (ELS ⁶ length = 13 lin.ft. min; 130 lin.ft. max.)	Length of ELS ⁶ Lip = 13 lin.ft. per each 1 cfs of inflow (13 lin.ft. min; 130 lin.ft. max.)
Construction Stage (Section 8)	Located outside the limits of disturbance and protected by ESC controls	Prevent soil compaction by heavy equipment
Typical Applications (Section 5)	Adjacent to stream or wetland buffer or forest conservation area	Treat small areas of IC (e.g., 5,000 sf) and/or turf-intensive land uses (sports fields, golf courses) close to source
Compost Amendments (Section 6.1)	No	Yes (B, C, and D soils) ⁵
Boundary Spreader (Section 6.3)	GD ⁶ at top of filter	GD ⁶ at top of filter PB ⁶ at toe of filter

¹ A minimum of 1% is recommended to ensure positive drainage.
² For Conservation Areas with a varying slope, a pro-rated length may be computed only if the first 10 ft. is 2% or less.
³ Vegetative Cover is described in Section 6.2.
⁴ Where the Conserved Open Space is a mixture of native grasses, herbaceous cover and forest (or re-forested area), the length of the ELS ⁶ Lip can be established by computing a weighted average of the lengths required for each vegetation type. Refer to Section 6.3 for design criteria
⁵ The plan approving authority may waive the requirement for compost amended soils for filter strips on B soils under certain conditions (see Section 6.1).
⁶ ELS = Engineered Level Spreader; GD = Gravel Diaphragm; PB = Permeable Berm.

Sheet Flow to a Vegetated Filter Strip or Conserved Open Space

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 2

Key Design Consideration: Nomenclature!



Sheet Flow to a Vegetated Filter Strip or Conserved Open Space

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 2

Key Design Considerations:

- Minimum filter strip length (based on filter strip or open space grade)

A boundary zone (or pre-treatment area) is contained in first 10 ft at minimum grade (2 – 4%)

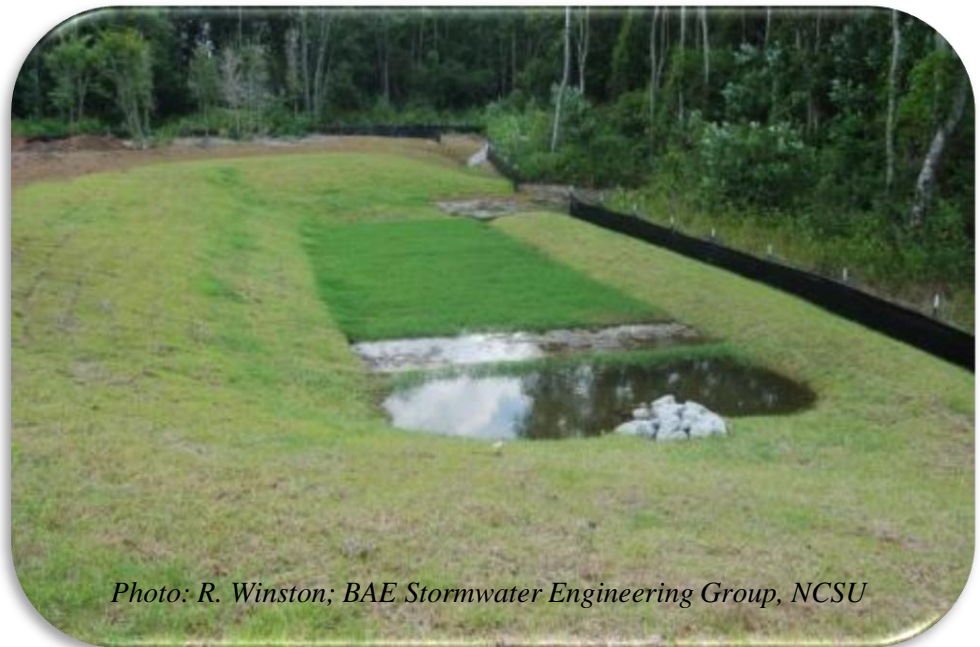


Photo: R. Winston; BAE Stormwater Engineering Group, NCSU

Sheet Flow to a Vegetated Filter Strip or Conserved Open Space

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 2



Key Design Consideration:
Maximum drainage area
limits for Sheet Flow and
Concentrated Flow (based
on 130' max ELS)

Photo: R. Winston; BAE Stormwater Engineering Group, NCS

Sheet Flow to a Vegetated Filter Strip or Conserved Open Space

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 2

Key Design Consideration:

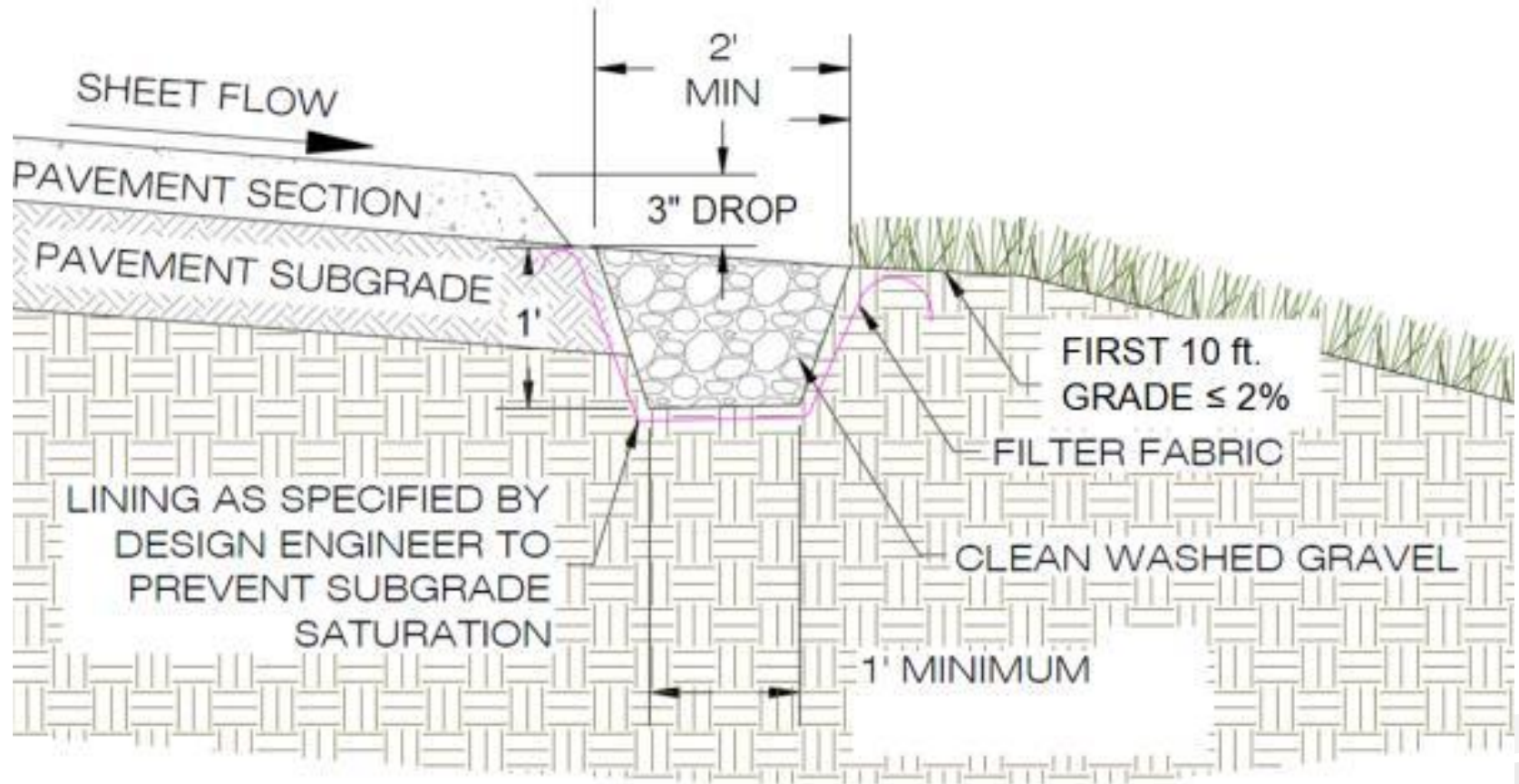
Use of gravel diaphragm at upper edge of Filter Strip or Conserved Open Space to ensure runoff enters filter strip or open space as sheet flow



Photo: BAE Stormwater Engineering Group, NCSU

Sheet Flow to a Vegetated Filter Strip or Conserved Open Space

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 2

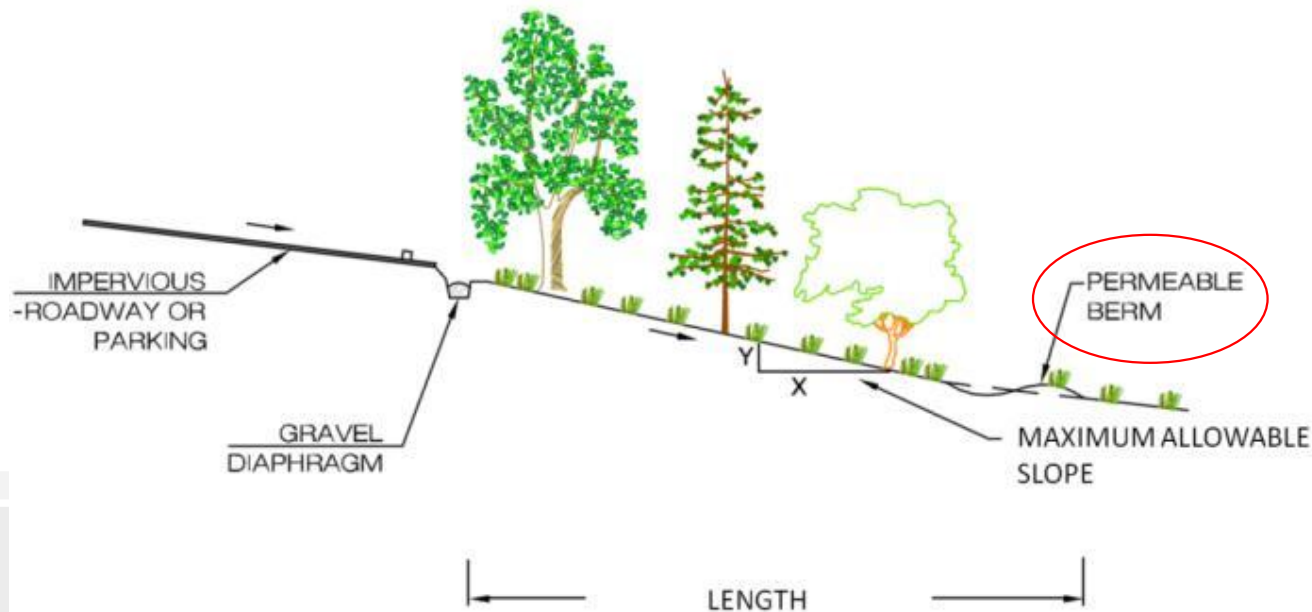


Sheet Flow to a Vegetated Filter Strip or Conserved Open Space

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 2

Key Design Consideration:

Policy for conditions downstream edge of filter strip or conserved open space to require permeable berm



Sheet Flow to a Vegetated Filter Strip or Conserved Open Space

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 2

Key Design Consideration:

Establish or maintain good vegetative cover and limit grade to keep flow velocity low and maintain sheet flow

- Gravel diaphragm
- Flat grade
- Thick no-mow (low maintenance) vegetation.



Sheet Flow to a Vegetated Filter Strip or Conserved Open Space

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 2

Key Design Consideration:

Engineered Level Spreader (ELS) combined with forebay, energy dissipator, rigid lip, & gravel diaphragm

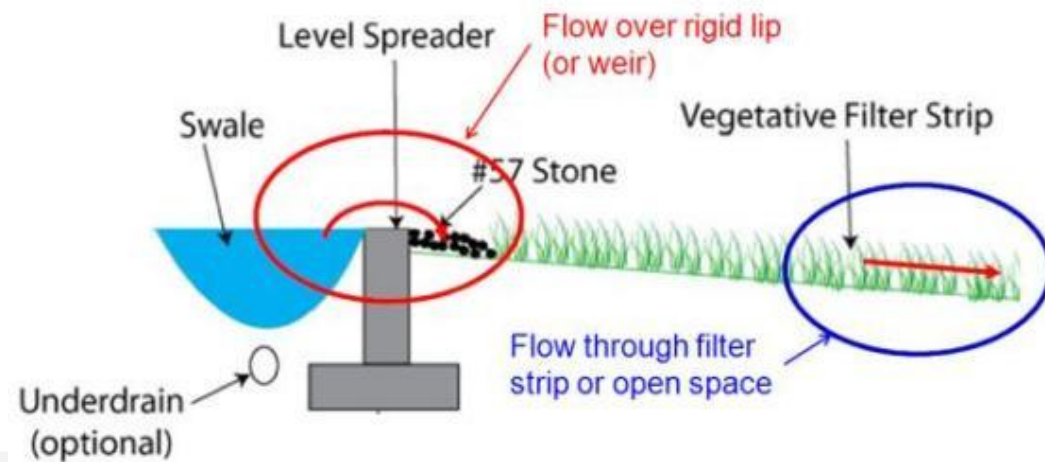


Photo: R. Winston; BAE Stormwater Engineering Group, NCSU

ENVIRONMENTAL QUALITY

Sheet Flow to a Vegetated Filter Strip or Conserved Open Space

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 2

Key Design Consideration:

- Length of ELS = 13 ft for every 1 cfs of design flow (recommended maximum = 130 ft);
- Design length based on:
 - Limiting flow velocity over rigid lip (weir) to 1 ft/s
 - Depth of flow over (broad crested) weir to approx. 1 inch
 - Maintain non-erosive design velocity (grass cover) < 4 fps

Sheet Flow to a Vegetated Filter Strip or Conserved Open Space

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 2

Key Design Consideration:



Photo: R. Winston; BAE Stormwater Engineering Group, NCSU

Grass Channels

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 3



Grass Channels

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 3

Summary of Stormwater Functions ¹



Stormwater Function	HSG Soils A and B		HSG Soils C and D	
	No CA ²	With CA	No CA	With CA
Annual Runoff Volume Reduction (RR)	20%	NA ³	10%	30%
Total Phosphorus (TP) EMC Reduction ⁴ by BMP Treatment Process	15%		15%	
Total Phosphorus (TP) Mass Load Removal	32%		24% (no CA) to 41% (with CA)	
Total Nitrogen (TN) EMC Reduction ⁴ by BMP Treatment Process	20%		20%	
Total Nitrogen (TN) Mass Load Removal	36%		28% (no CA) to 44% (with CA)	
Channel & Flood Protection	Partial. Designers can use the RRM spreadsheet to adjust curve number for each design storm for the contributing drainage area, based on annual runoff reduction achieved. Also, the Tc for the grass swale flow path should reflect the slope and appropriate roughness for the intended vegetative cover.			

¹ CWP and CSN (2008) and CWP (2007).

² CA= Compost Amended Soils, see Stormwater Design Specification No. 4.

³ Compost amendments are generally not applicable for A and B soils, although it may be advisable to incorporate them on mass-graded and/or excavated soils to maintain runoff reduction rates. In these cases, the 30% runoff reduction rate may be claimed, regardless of the pre-construction HSG.

⁴ Change in event mean concentration (EMC) through the practice. Actual nutrient mass load removed is the product of the pollutant removal rate and the runoff volume reduction rate (see Table 1 in the *Introduction to the New Virginia Stormwater Design Specifications*).

Grass Channels

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 3

Grass Channel design criteria:

- **Bottom width (4 ft min, 8 ft max) set to maintain treatment volume (T_v)¹ peak flow ($Q_{1\text{-inch}}$) at less than 4 inches depth and ≤ 1 ft/s velocity.**
- **Channel side-slopes 3H:1V or flatter**
- **Maximum total contributing drainage area ≤ 5 acres**

¹ Design should consider entire T_v of contributing drainage area (rather than $T_{v_{BMP}}$ which would reflect T_v decrease based on upstream runoff reduction practices) in order to ensure non-erosive conveyance during all design storm conditions.



Grass Channels

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 3

Grass Channel design criteria:

- Longitudinal slope $\leq 4\%$. (Check dams may be used to reduce effective slope to meet limiting velocity requirements)
- Dimensions to ensure flow velocity non-erosive during 2 & 10-year design storm and 10-year design flow contained within channel (minimum of 0.3 ft freeboard)

Grass Channels

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 3

Key Design Consideration:

- Maximum width of bottom of trapezoidal geometry should be limited to discourage braided flow and preferential channeling within grass channel



Grass Channels

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 3

Key Design Consideration:

- Most grass channels gradually evolve to parabolic shape in response to flow characteristics
- Water quality grass channel should still be constructed trapezoidal

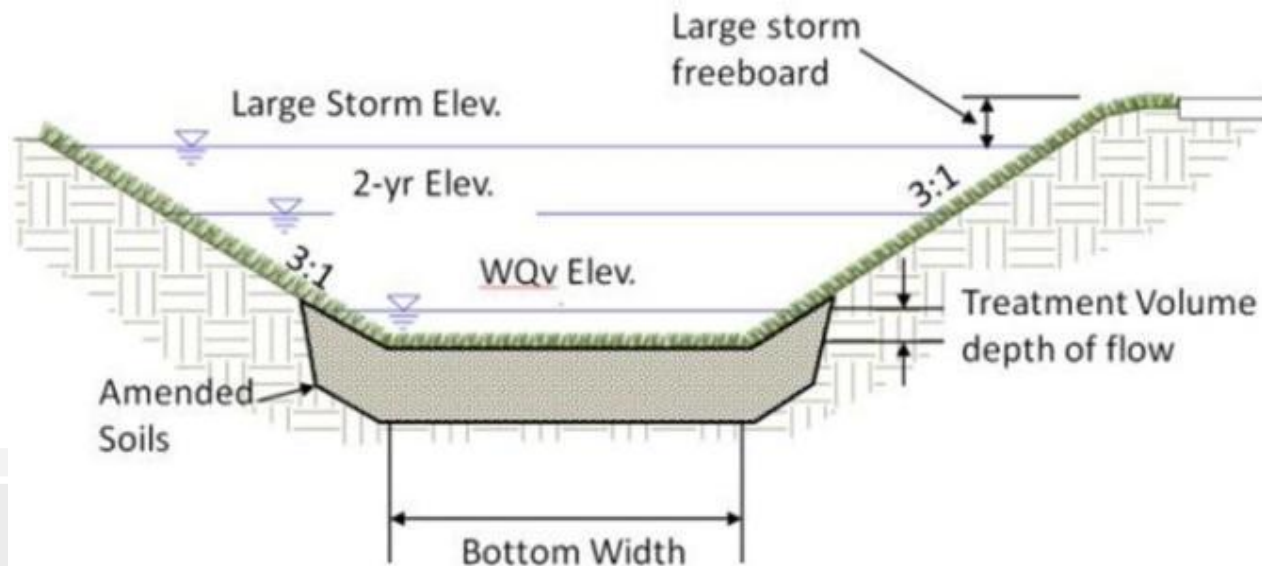


Grass Channels

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 3

Key Design Consideration: Soils

- Runoff reduction (RR) capacity greatest in HSG A soils
- RR gradually decreases in HSG B, C and D soils
- HSG C and D soils lining bottom of Grass Channel



nce

Soil Amendments

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 4



Soil Amendments

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 4

Summary of Stormwater Functions ¹

Stormwater Function	HSG Soils A and B		HSG Soils C and D	
	No CA ²	With CA	No CA	With CA
Annual Runoff Volume Reduction (RR)				
Simple Rooftop Disconnection	50%	NA ³	25%	50%
Filter Strip	50%	NA ³	NA ⁴	50%
Grass Channel	20%	NA ³	10%	30%
Total Phosphorus (TP) EMC Reduction ⁴ by BMP Treatment Practice	0		0	
Total Phosphorus (TP) Mass Load Removal	Same as for RR (above)		Same as for RR (above)	
Total Nitrogen (TN) EMC Reduction by BMP Treatment Practice	0		0	
Total Nitrogen (TN) Mass Load Removal	Same as for RR (above)		Same as for RR (above)	
Channel Protection & Flood Mitigation	Partial. Designers can use the RRM spreadsheet to adjust the curve number for each design storm for the contributing drainage area, based on annual runoff volume reduction achieved.			

¹ CWP and CSN (2008), CWP (2007)

² CA = Compost Amended Soils,

³ Compost amendments are generally not applicable for A and B soils, although it may be advisable to incorporate them on mass-graded B soils to maintain runoff reduction rates.

⁴ Filter strips in HSG C and D should use composted amended soils to enhance runoff reduction capabilities. See Stormwater Design Specification No. 2: Sheetflow to Vegetated Filter Strip or Conserved Open Space.

Soil Amendments

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 4

Short-Cut Method to Determine Compost and Incorporation Depths

	Contributing Impervious Cover to Soil Amendment Area Ratio ¹			
	IC/SA = 0 ²	IC/SA = 0.5	IC/SA = 0.75	IC/SA = 1.0 ³
Compost (in) ⁴	2 to 4 ⁵	3 to 6 ⁵	4 to 8 ⁵	6 to 10 ⁵
Incorporation Depth (in)	6 to 10 ⁵	8 to 12 ⁵	15 to 18 ⁵	18 to 24 ⁵
Incorporation Method	Rototiller	Tiller	Subsoiler	Subsoiler

Notes:

¹ IC = contrib. impervious cover (sq. ft.) and SA = surface area of compost amendment (sq. ft.)

² For amendment of compacted lawns that do not receive off-site runoff

³ In general, IC/SA ratios greater than 1 should be avoided, unless applied to a simple rooftop disconnection

⁴ Average depth of compost added

⁵ Lower end for B soils, higher end for C/D soils

Soil Amendments

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 4

BMP Design Specification No. 4:

Criteria for applicability and design related to soil testing and compost material specifications.



Photo Credit: Richard McLaughlin, Ph.D., North Carolina State University

Soil Amendments

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 4

BMP Design Specification No. 4:

Criteria for applicability
and design related to
incorporating amendments



*Photo Credit: Jeremy Balousek, P.E., Dane County, WI Land and
Water Resources Department*

Vegetated Roof

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 5



Vegetated Roof

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 5

Summary of Stormwater Functions ¹

Stormwater Function	Level 1 Design	Level 2 Design
Annual Runoff Volume Reduction (RR)	45%	60%
Total Phosphorus (TP) EMC Reduction ² by BMP Treatment Process	0	0
Total Phosphorus (TP) Mass Load Removal	45%	60%
Total Nitrogen (TN) EMC Reduction ² by BMP Treatment Process	0	0
Total Nitrogen (TN) Mass Load Removal	45%	60%
Channel Protection & Flood Mitigation ³	Use the following Curve Numbers (CN) for Design Storm events: 1-year storm = 64; 2-year storm = 66; 10-year storm = 72; and the 100 year storm = 75	

¹ Sources: CWP and CSN (2008) and CWP (2007).

² Moran et al (2004) and Clark et al (2008) indicate no nutrient reduction or even negative nutrient reduction (due to leaching from the media) in early stages of vegetated roof development.

³ See Miller (2008), NVRC (2007) and MDE (2008)

Vegetated Roof

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 5

Vegetated Roof Design Criteria

Level 1 Design (RR:45; TP:0; TN:0)	Level 2 Design (RR: 60; TP:0; TN:0)
$T_v = 1.0 (R_v)^1 (A)/12$	$T_v = 1.1 (R_v)^1 (A)/12$
Depth of media up to 4 inches	Media depth 4 to 8 inches
Drainage System	2-inch stone drainage layer
No more than 20% organic matter in media	No more than 10% organic matter in media
All Designs: Must be in conformance to ASTM (2005) International Green (Vegetated) Roof Stds.	
¹ R _v represents the runoff coefficient for a conventional roof, which will usually be 0.95. The runoff reduction rate applied to the vegetated roof is for “capturing” the Treatment Volume (T _v) compared to what a conventional roof would produce as runoff.	

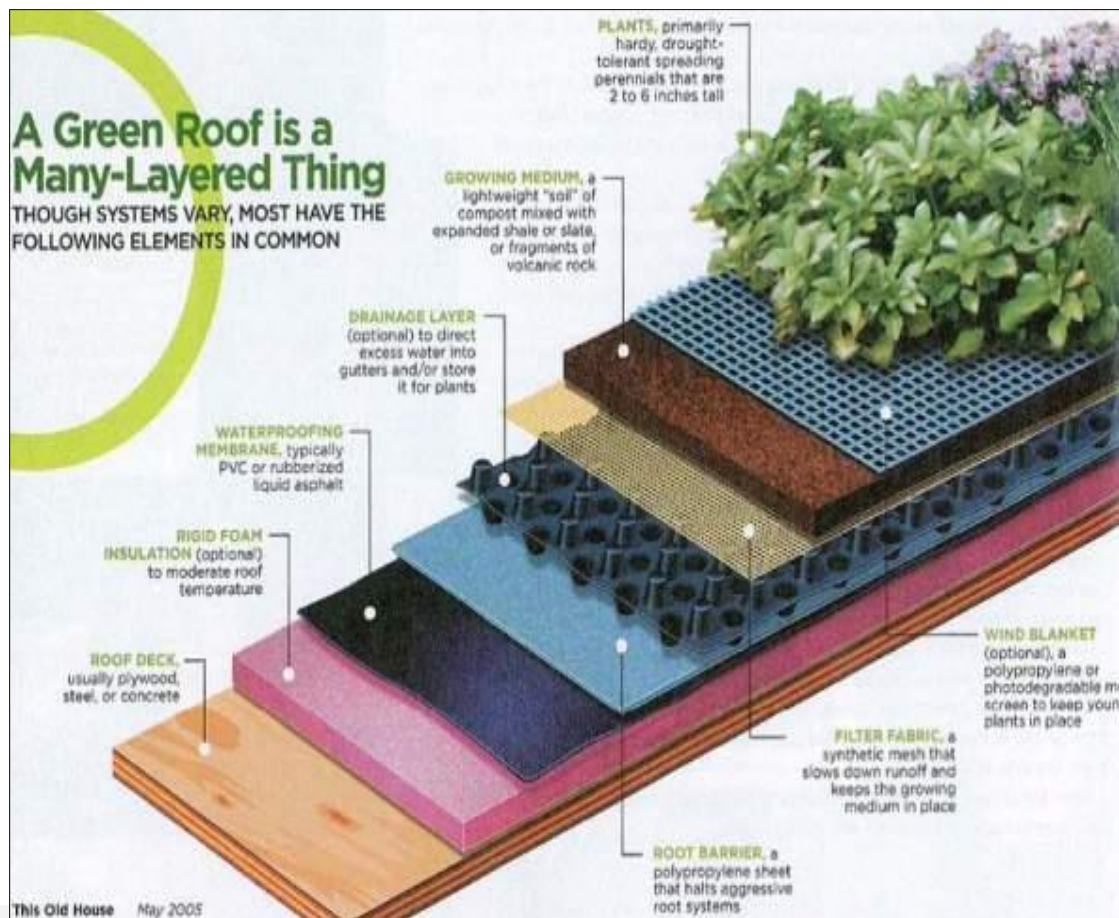


Vegetated Roof

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 5

Functional Elements of Vegetated Roof:

- Deck layer
- Waterproofing layer
- Insulation layer
- Root barrier
- Drainage layer and drainage system
- Root permeable filter fabric
- Growing media
- Plant pallet



Vegetated Roof

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 5

Key Design Considerations:

- Structural capacity of roof
- Roof Access: construct & maintain
- Setbacks from electrical and HVAC systems, and vegetation-free zones (firebreaks, perimeter, etc.)



Rainwater Harvesting

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 6



Rainwater Harvesting

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 6

Summary of Stormwater

Stormwater Function	Functions ¹	Performance
Annual Runoff Volume Reduction (RR)		Variable up to 90% ²
Total Phosphorus (TN) EMC Reduction ¹ by BMP Treatment Process		0%
Total Phosphorus (TN) Mass Load Removal		Variable up to 90% ²
Total Nitrogen (TN) EMC Reduction ¹ by BMP Treatment Process		0%
Total Nitrogen (TN) Mass Load Removal		Variable up to 90% ²
Channel Protection		Partial: reduced curve numbers and increased Time of Concentration
Flood Mitigation		Partial: reduced curve numbers and increased Time of Concentration

¹ Nutrient mass load removal is equal to the runoff volume reduction rate. Zero pollutant removal rate is applied to the rainwater harvesting system only. Nutrient removal rates for secondary practices will be in accordance with the design criteria for those practices.

² Credit is variable and determined using the Cistern Design Spreadsheet. Credit up to 90% is possible if all water from storms with rainfall of 1 inch or less is used through demand, and the tank is sized such that no overflow from this size event occurs. The total credit may not exceed 90%.

Rainwater Harvesting

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 6

Physical Feasibility and Applications

- Available space
- Site topography and hydraulic head
- Water table
- Soils
- Proximity of underground utilities.
- Contributing drainage area
- Rooftop material
- Rainwater water quality
- Hotspot land uses
- Setbacks from buildings
- Vehicle loading

Rainwater Harvesting

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 6

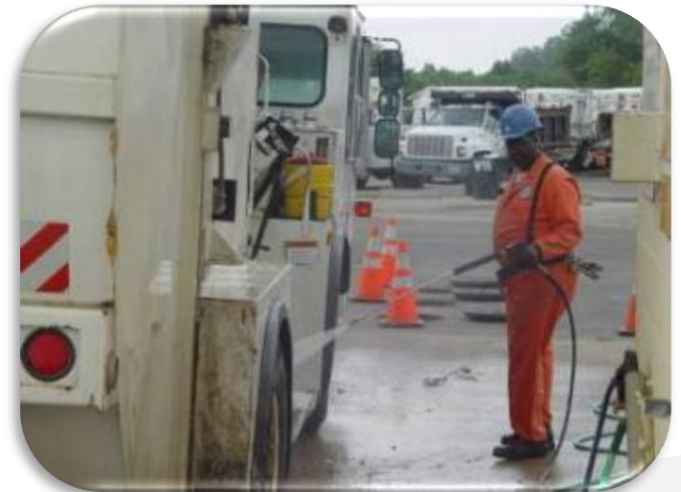
Annual runoff reduction volume credit only
awarded for dedicated year-round water
drawdown/demand



Laundry washing



Toilet flushing



Vehicle washing

Rainwater Harvesting

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 6

Seasonal uses must be supplemented with runoff reduction drawdown practice



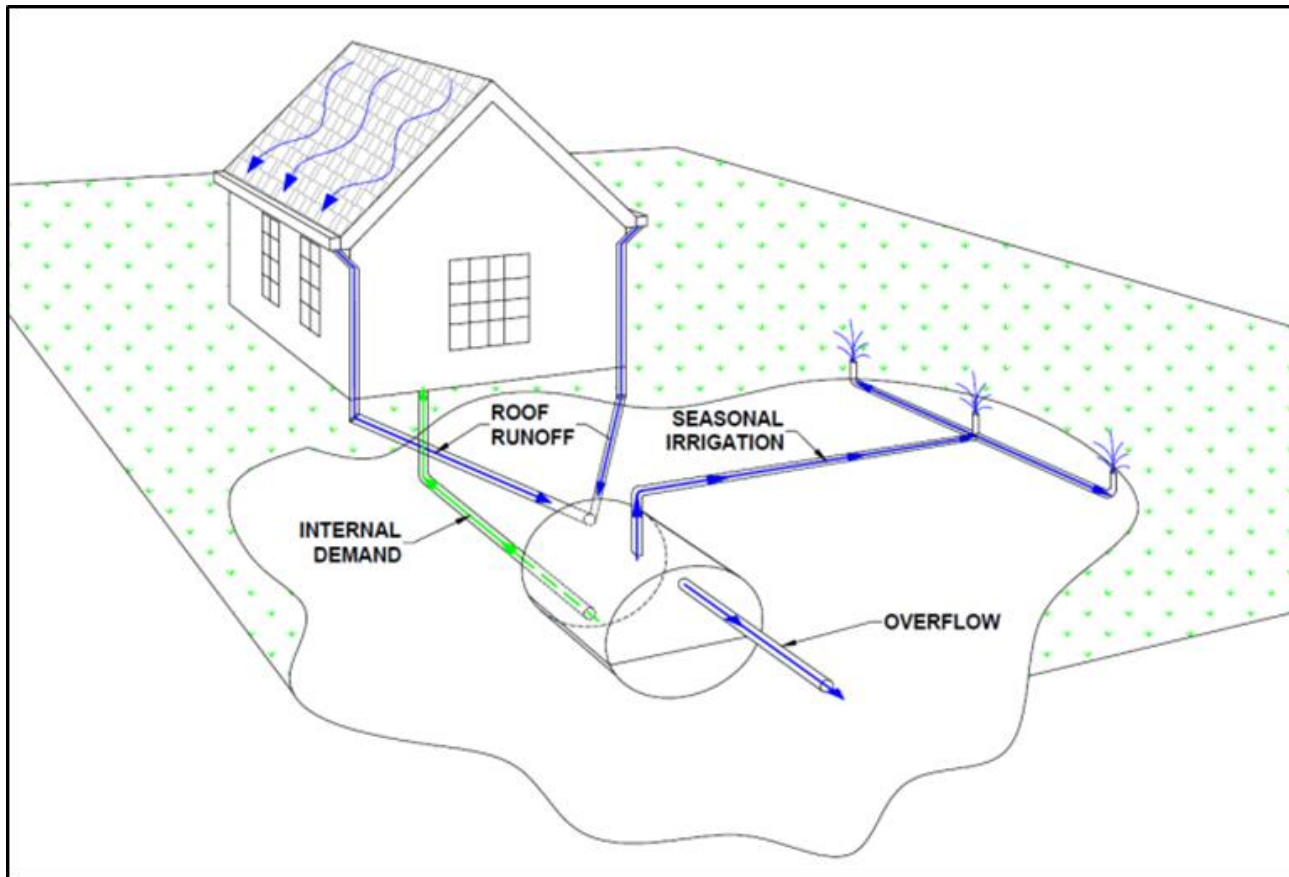
Cooling tower make-up water



Irrigation

Rainwater Harvesting

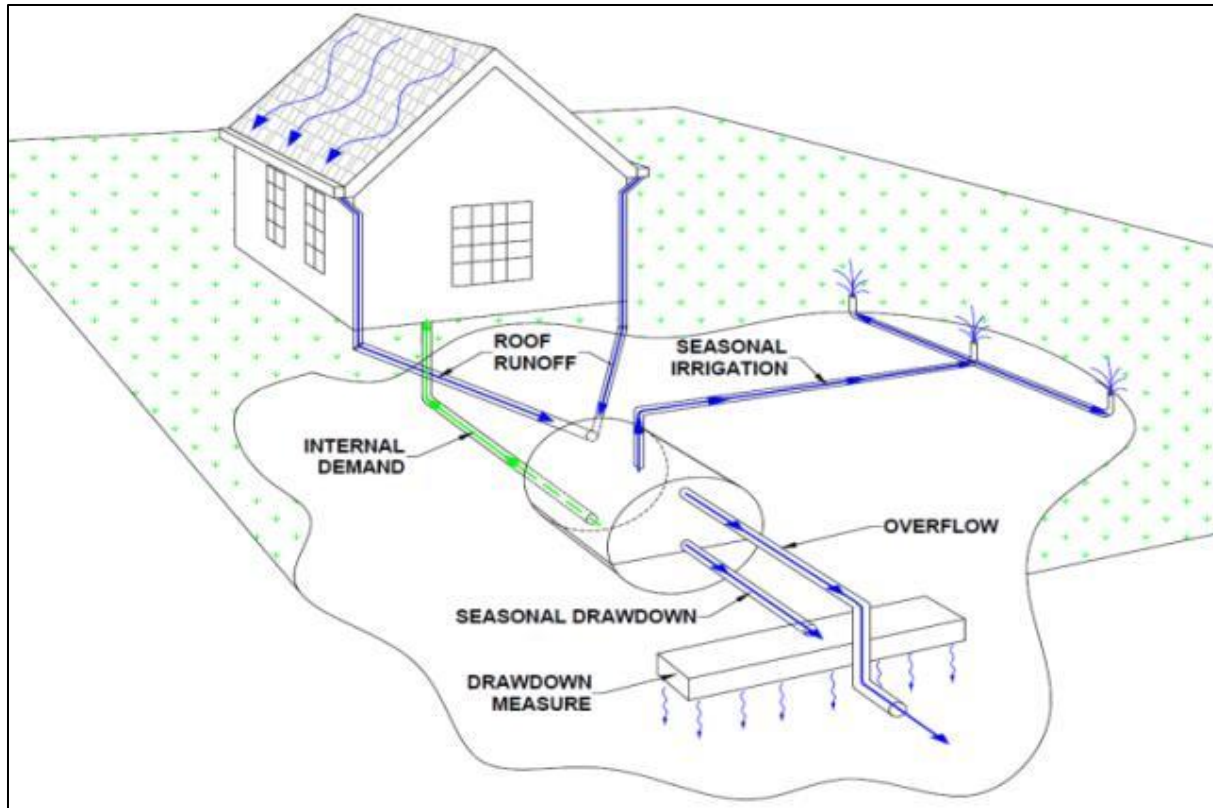
VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 6



Configuration 1: Year-round indoor use with optional seasonal outdoor use

Rainwater Harvesting

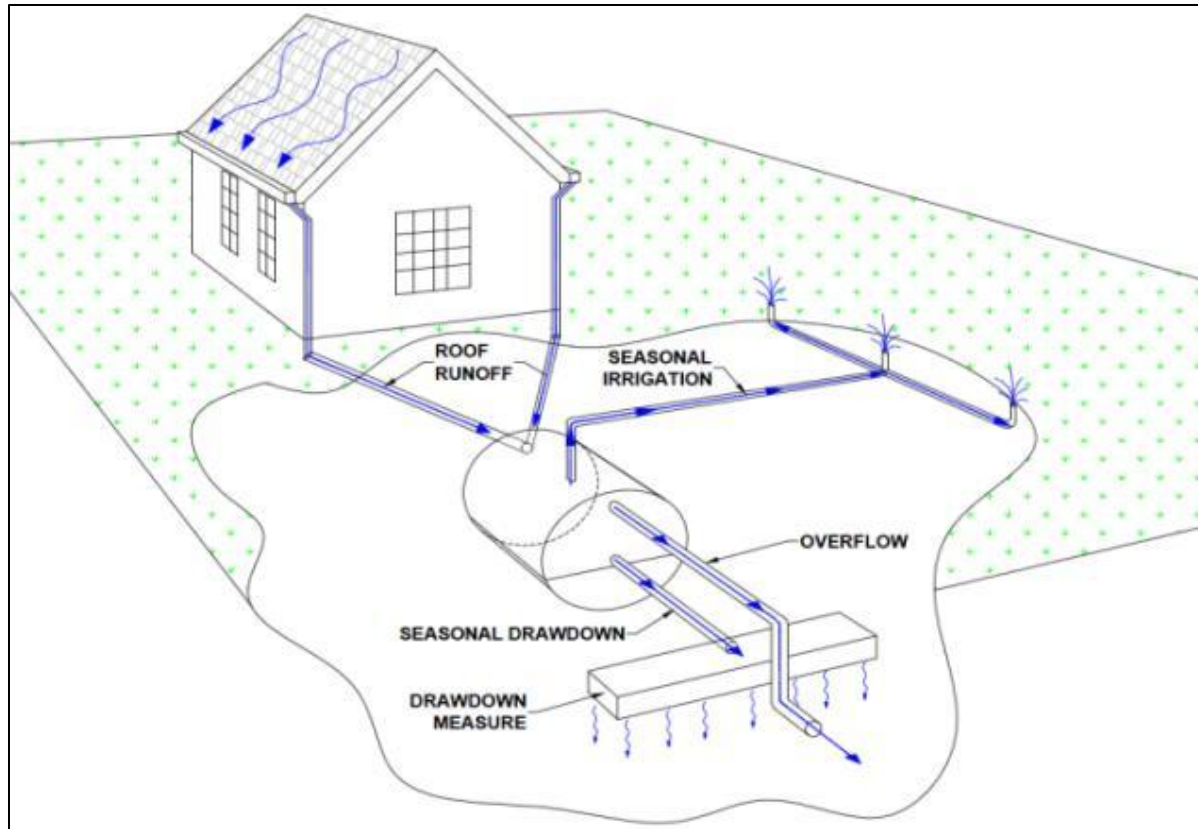
VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 6



Configuration 2: Year-round indoor use with seasonal indoor and/or outdoor uses that are supplemented with a secondary runoff reduction drawdown practice

Rainwater Harvesting

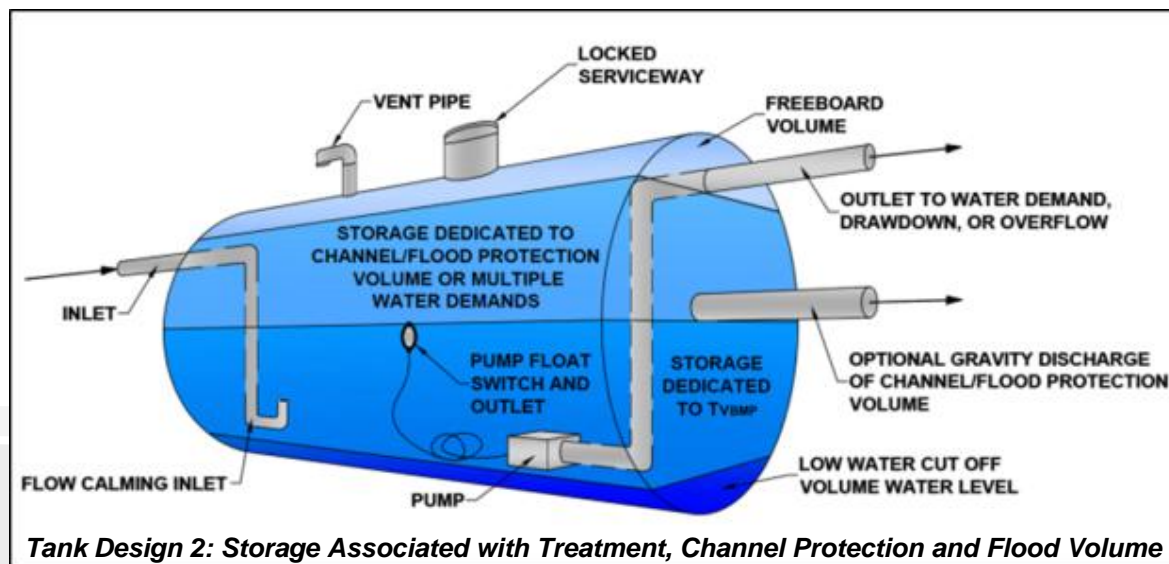
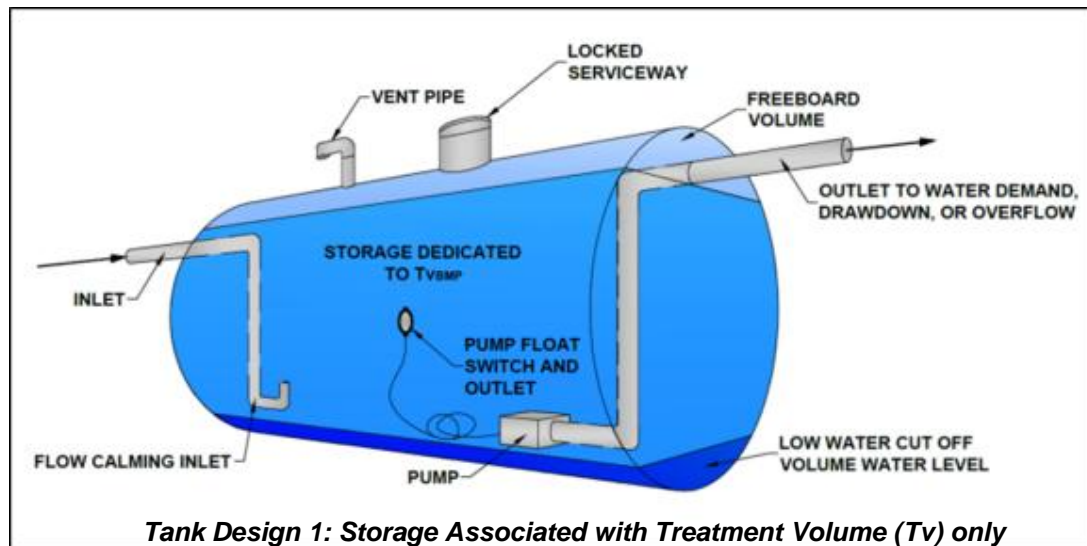
VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 6



Configuration 3: Seasonal only indoor and/or outdoor uses that are supplemented with a secondary runoff reduction drawdown practice

Rainwater Harvesting

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 6



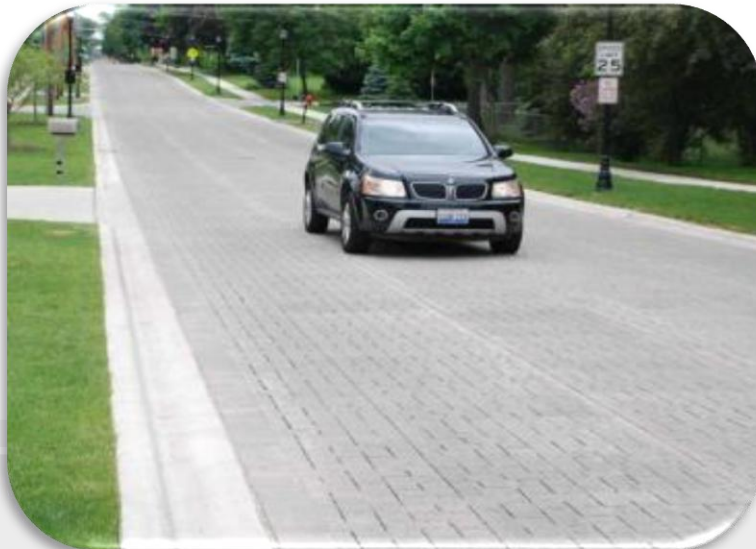
Permeable Pavement

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 7



Permeable Pavement

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 7



Summary of Stormwater Functions ¹

Stormwater Function	Level 1 Design	Level 2 Design
Annual Runoff Volume Reduction (RR)	45%	75%
Total Phosphorus (TP) EMC Reduction ¹ by BMP Treatment Process	25%	25%
Total Phosphorus (TP) Mass Load Removal	59%	81%
Total Nitrogen (TN) EMC Reduction ¹	25%	25%
Total Nitrogen (TN) Mass Load Removal	59%	81%
Channel Protection	<ul style="list-style-type: none"> • Use <u>VRRM</u> Compliance spreadsheet to calculate a Curve Number (CN) adjustment²; OR • Design extra storage in the stone underdrain layer and peak rate control structure (optional, as needed) to accommodate detention of larger storm volumes. 	
Flood Mitigation	Partial. May be able to design additional storage into the reservoir layer by adding perforated storage pipe or chambers.	

¹ Change in event mean concentration (EMC) through the practice. Actual nutrient mass load removed is the product of the removal rate and the runoff reduction rate (see Table 1 in the *Introduction to the New Virginia Stormwater Design Specifications*).

² NRCS TR-55 Runoff Equations 2-1 thru 2-5 and Figure 2-1 can be used to compute a curve number adjustment for larger storm events based on the retention storage provided by the practice(s).

Sources: CWP and CSN (2008) and CWP (2007)

Permeable Pavement

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 7

Permeable Pavement Design Criteria

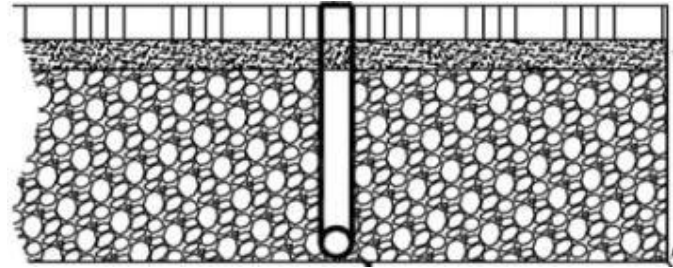


Level 1 Design	Level 2 Design
$T_{V_{BMP}} = (1)(R_v)(A) / 12 + \text{any remaining volume from an upstream BMP(s)}^1$	$T_{V_{BMP}} = (1.1)(R_v)(A) / 12$
Soil infiltration is less than 0.5 in./hr.	Soil infiltration rate exceeds 0.5 in./hr to remove underdrain requirement, or a drawdown design in accordance with Section 6 .
Underdrain required	1. No underdrain; OR 2. If an underdrain is used, a 12-inch (minimum) stone reservoir infiltration sump below the underdrain invert that meets the drawdown requirements of Section 6 must be provided; OR 3. The T_v stone reservoir volume has at least a 48-hour drain time, as regulated by a control structure.
CDA^1 = The permeable pavement area plus upgradient parking, as long as the ratio of external contributing area to permeable pavement does not exceed 2:1.	CDA = The permeable pavement area;
¹ The contributing drainage area to the permeable pavements should be limited to paved surfaces in order to avoid sediment wash-on, and. When pervious areas are conveyed to permeable pavement, sediment source controls and/or pre-treatment must be provided. The pre-treatment may qualify for a runoff reduction credit if designed accordingly.	

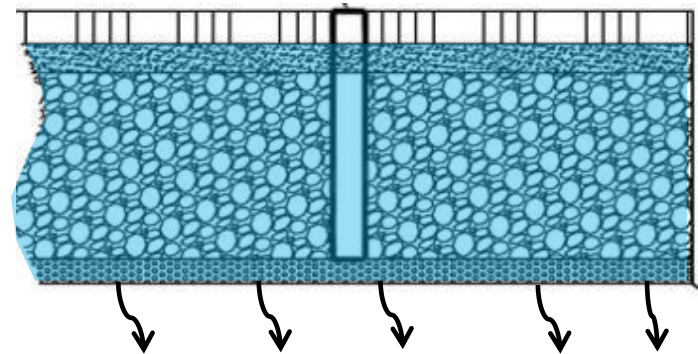
Permeable Pavement

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 7

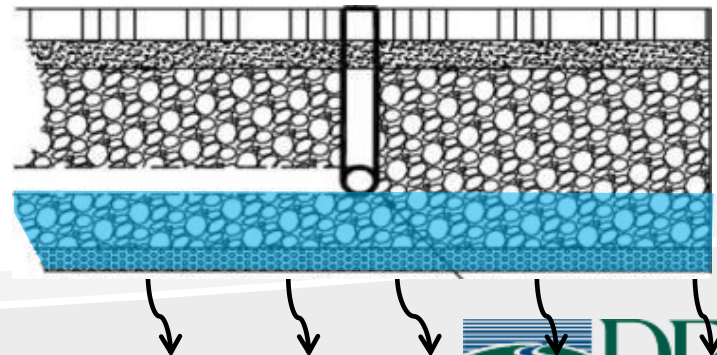
Level 1



Level 2 (infiltration)



Level 2 (infiltration sump)



Permeable Pavement

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 7

Type of pavement materials



Concrete Grid Pavers



Pervious Concrete



Porous Asphalt



**Permeable
Interlocking
Concrete Pavers**



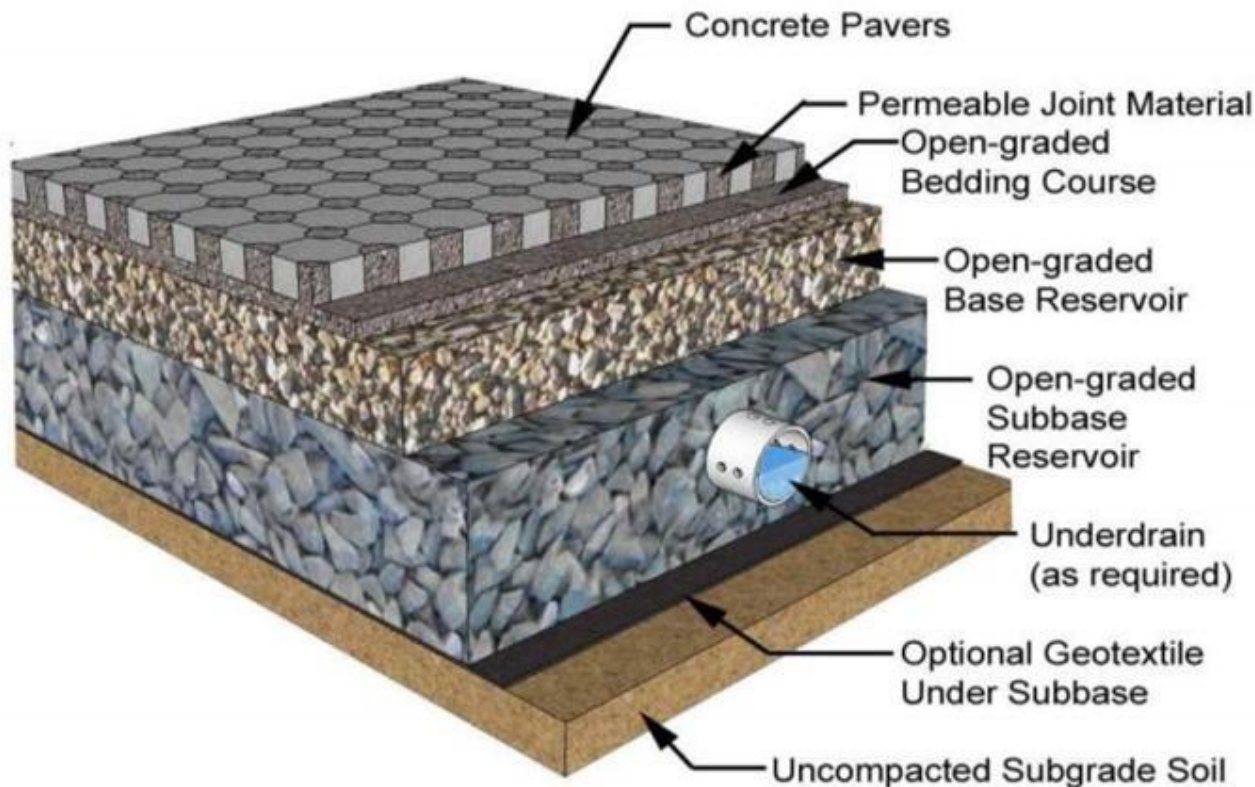
Pervious Composites



**Permeable Rubber
Overlays**

Permeable Pavement

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 7



Permeable Pavement

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 7

- Key Design Consideration: stone reservoir depth, d_p

$$d_p = \frac{\{(d_c \times R) + P - (i/2 \times t_f)\}}{V_r}$$

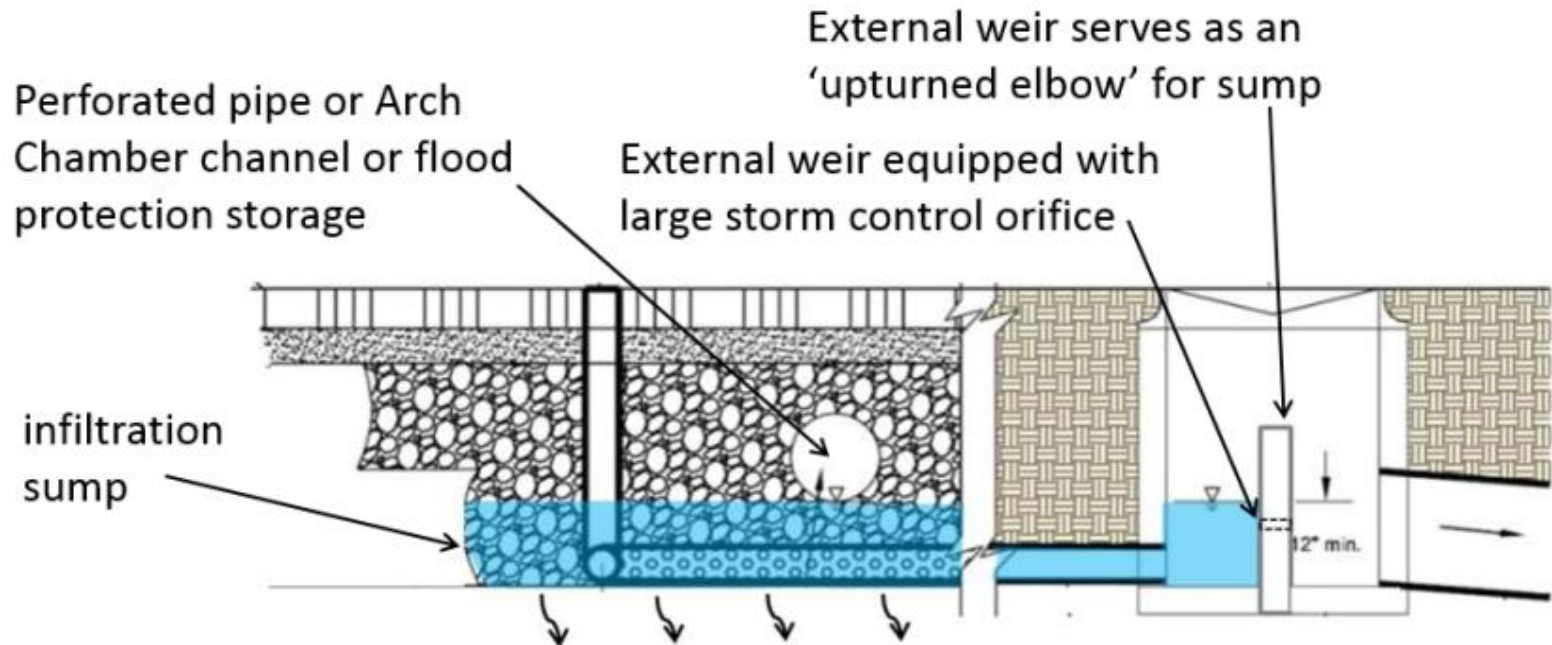
Where:

- d_p = Depth of the stone reservoir layer (ft.)
- d_c = The depth of runoff from the contributing drainage area (not including the permeable paving surface) for the Treatment Volume (T_v/A_c), or other design storm (ft.)
- R = A_c/A_p = The ratio of the contributing drainage area (A_c , not including the permeable paving surface) to the permeable pavement surface area (A_p)
- P = The rainfall depth (in feet) for the Treatment Volume (Level 1 = 1 inch (0.08 ft); Level 2 = 1.1 inch (0.09 ft)) or other design storm
- i = The field-verified infiltration rate for native soils (ft./day)
- t_f = The time to fill the reservoir layer (day) – typically 2 hours or 0.083 day
- V_r or η_r = Porosity (or void ratio) of reservoir layer (0.4)

Permeable Pavement

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 7

Key Design Consideration: 'Upturned Elbow'



Permeable Pavement

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 7

Key Design Consideration: External Drainage Areas

- **The maximum external drainage area is limited to ratio with area of permeable pavement: 2:1**
- In all cases, external drainage areas should be limited to impervious surfaces to reduce potential sediment loading



Permeable Pavement

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 7

Key Design Consideration: Pavement Structural Design

Thickness of permeable pavement and reservoir layer must be sized to support structural loads



Four primary design elements:

- Anticipated traffic loads
- Underlying soil properties
- Environmental/climate factors
- Surface, bedding, and reservoir strength coefficients and layer thicknesses (strength coefficients vary for materials used)

Permeable Pavement

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 7

Key Design Consideration: Maintenance Agreements

Permeable Pavement (like all BMPs) must have a maintenance agreement, and should include provisions for owner awareness of routine (frequent) and infrequent maintenance requirements.



Permeable Pavement

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 7

Key Design Consideration: Construction

- Contractor Qualifications
- Material specifications



Infiltration Practices

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 8



Infiltration Practices

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 8

Summary of Stormwater Functions ¹

Stormwater Function	Level 1 Design	Level 2 Design
Annual Runoff Volume Reduction (RR)	50%	90%
Total Phosphorus (TP) EMC Reduction ¹ by BMP Treatment Process	25%	25%
Total Phosphorus (TP) Mass Load Removal	63%	93%
Total Nitrogen (TN) EMC Reduction ¹ by BMP Treatment Process	15%	15%
Total Nitrogen (TN) Mass Load Removal	57%	92%
Channel and Flood Protection	<ul style="list-style-type: none"> Use the Virginia Runoff Reduction Method (VRRM) Compliance Spreadsheet to calculate the Curve Number (CN) Adjustment OR Design for extra storage (optional; as needed) on the surface or in the subsurface storage volume to accommodate larger storm volumes, and use NRCS TR-55 Runoff Equations ² to compute the CN Adjustment. 	

¹ Change in the event mean concentration (EMC) through the practice. The actual nutrient mass load removed is the product of the removal rate and the runoff reduction (RR) rate (see Table 1 in the *Introduction to the New Virginia Stormwater Design Specifications*).

² NRCS TR-55 Runoff Equations 2-1 thru 2-5 and Figure 2-1 can be used to compute a curve number adjustment for larger storm events, based on the retention storage provided by the practice(s).



Infiltration Practices

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 8

Infiltration Practices Design Criteria

Level 1 Design (RR:50; TP:25; TN:15)	Level 2 Design (RR:90; TP:25; TN:15)
<u>Sizing:</u> $T_v = [(R_v)(A)/12] + \text{any remaining volume from upstream BMP(s)}$	<u>Sizing:</u> $T_v = [1.1(R_v)(A)/12] + \text{any remaining volume from upstream BMP(s)}$
At least two forms of pre-treatment (see Table 8.6)	At least three forms of pre-treatment (see Table 8.6)
Soil infiltration rate 1/2 to 1 in./hr. (see Section 6.1 & Appendix 8-A); number of tests depends on the scale (Table 8.4)	Soil infiltration rates of 1.0 to 4.0 in/hr (see Section 6.1 & Appendix 8-A); number of tests depends on the scale (Table 8.4)
Minimum of 2 feet between the bottom of the infiltration practice and the seasonal high water table or bedrock (Section 5)	
T_v infiltrates within 36 to 48 hours (Section 6.6)	
Building Setbacks – see Table 8.4	
All Designs are subject to hotspot runoff restrictions/prohibitions	



Infiltration Practices

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 8

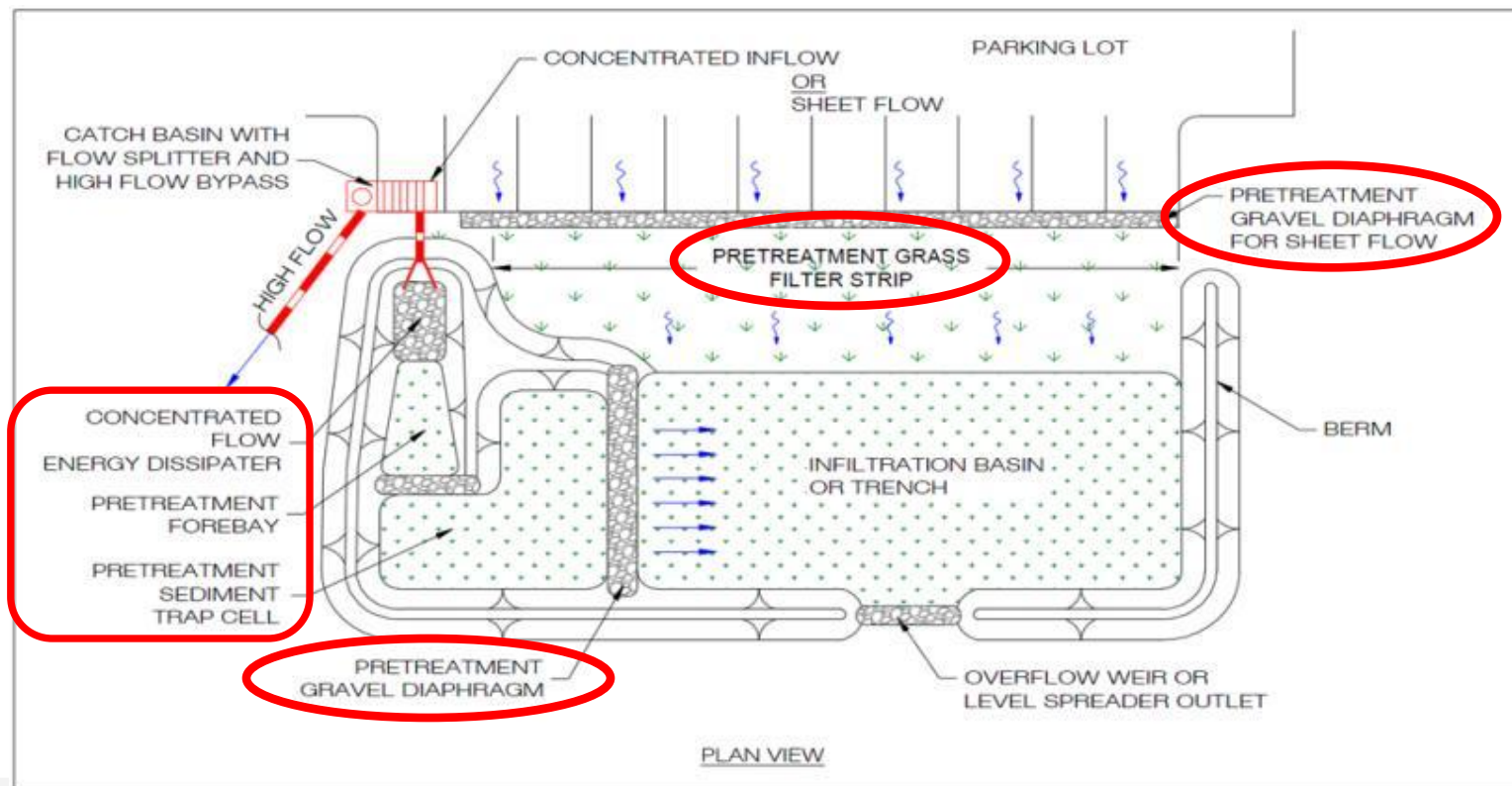
Key Design Considerations: Applicability

- *Soils*
- Minimum depth to water table or bedrock
- Use on urban soils/redevelopment sites
- High loading situations
- Groundwater protection

Infiltration Practices

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 8

Key Design Considerations: Pre-treatment



Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9



Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

Summary of Stormwater Functions ¹



Stormwater Function	Level 1 Design	Level 2 Design
Annual Runoff Volume Reduction (RR)	40%	80%
Total Phosphorus (TP) EMC Reduction ¹ by BMP Treatment Process	25%	50%
Total Phosphorus (TP) Mass Load Removal	55%	90%
Total Nitrogen (TN) EMC Reduction ¹ by BMP Treatment Process	40%	60%
Total Nitrogen (TN) Mass Load Removal	64%	90%
Channel and Flood Protection	<ul style="list-style-type: none"> • Use the Virginia Runoff Reduction Method (VRRM) Compliance Spreadsheet to calculate the Curve Number (CN) Adjustment OR • Design extra storage (optional; as needed) on the surface, in the engineered soil matrix, and in the stone/underdrain layer to accommodate a larger storm, and use NRCS TR-55 Runoff Equations² to compute the CN Adjustment. 	

¹ Change in event mean concentration (EMC) through the practice. Actual nutrient mass load removed is the product of the removal rate and the runoff reduction rate(see Table 1 in the *Introduction to the New Virginia Stormwater Design Specifications*).

² NRCS TR-55 Runoff Equations 2-1 thru 2-5 and Figure 2-1 can be used to compute a curve number adjustment for larger storm events based on the retention storage provided by the practice(s).

Sources: CWP and CSN (2008) and CWP (2007)

Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

Level 1 & 2 Bioretention Design Criteria:

- Micro-Bioretention (Raingardens)
- Bioretention

Urban Bioretention Design Criteria:

- Micro-Bioretention with provisions for
 - Urban Planter boxes
 - Expanded Tree Pits
 - Curb Extensions

Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

Micro-Bioretention Design Criteria

Level 1 Design (RR 40 TP: 25)	Level 2 Design (RR: 80 TP: 50)
<u>Sizing</u> : Filter surface area (sq. ft.) = 3% ² of the contributing drainage area (CDA).	<u>Sizing</u> : Filter surface area (sq. ft.) = 4% ² of the CDA (can be divided into different cells at downspouts).
Maximum contributing drainage area = 0.5 acres; 25% Impervious Cover (IC) ²	
One cell design (can be divided into smaller cells at downspout locations) ²	
Maximum Ponding Depth = 6 inches	
<u>Filter Media Depth</u> minimum = 18 inches; Recommended maximum = 36 inches	<u>Filter Media Depth</u> minimum = 24 inches; Recommended maximum = 36 inches
<u>Media</u> : mixed on-site or supplied by vendor	<u>Media</u> : supplied by vendor
All Designs: Media mix tested for an acceptable phosphorus index (P-Index) of between 10 and 30, OR Between 7 and 23 mg/kg of P in the soil media	
<u>Sub-soil testing</u> : not needed if an underdrain is used; Min infiltration rate > 1 inch/hour in order to remove the underdrain requirement.	<u>Sub-soil testing</u> : one per practice; Min infiltration rate > 1/2 inch/hour; Min infiltration rate > 1 inch/hour in order to remove the underdrain requirement.
<u>Underdrain</u> : corrugated HDPE or equivalent.	<u>Underdrain</u> : corrugated HDPE or equivalent, with a minimum 6-inch stone sump below the invert; OR none, if soil infiltration requirements are met
<u>Clean-outs</u> : not needed	
<u>Inflow</u> : <u>sheetflow</u> or roof leader	
<u>Pretreatment</u> : external (leaf screens, grass filter strip, energy dissipater, etc.).	<u>Pretreatment</u> : external <i>plus</i> a grass filter strip
<u>Vegetation</u> : turf, herbaceous, or shrubs (min = 1 out of those 3 choices).	<u>Vegetation</u> : turf, herbaceous, shrubs, or trees (min = 2 out of those 4 choices).
<u>Building setbacks</u> : 10 feet down-gradient; 25 feet up-gradient	
¹ Consult Appendix 9-A for design criteria for Urban Bioretention Practices.	
² Micro-Bioretention (Rain Gardens) can be located at individual downspout locations to treat up to 1,000 sq. ft. of impervious cover (100% IC); the surface area is sized as 5% of the roof area (Level 1) or 6% of the roof area (Level 2), with the remaining Level 1 and Level 2 design criteria as provided in Table 9.2 . If the Rain Garden is located so as to capture multiple rooftops, driveways, and adjacent pervious areas, the sizing rules within Table 9.2 should apply.	





Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

Key Design Considerations:

Micro-Bioretention

- Sizing based on simple surface area as % of CDA (not Tv_{BMP})
- New ('14) specs modified so 'micro' and 'urban' consistent to avoid 'cherry picking' smaller design for relative scale of applications
- Level 1 & Level 2 Designs

Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

Bioretention Design Criteria

Level 1 Design (RR 40 TP: 25)	Level 2 Design (RR: 80 TP: 50)
Sizing (Section 6.1): $TVEMP = [(1)(Rv)(A) / 12] + \text{any remaining volume from upstream BMP}$ Surface Area (sq. ft.) = $TVEMP / \text{Storage Depth}^1$	Sizing (Section 6.1): $TVEMP = [(1.25)(Rv)(A) / 12] + \text{any remaining volume from upstream BMP}$ Surface Area (sq. ft.) = $TVEMP / \text{Storage Depth}^1$
Recommended maximum contributing drainage area = 2.5 acres	
Maximum Ponding Depth = 6 to 12 inches ²	Maximum Ponding Depth = 6 to 12 inches ²
Filter Media Depth minimum = 24 inches; recommended maximum = 6 feet	Filter Media Depth minimum = 36 inches; recommended maximum = 6 feet
Media & Surface Cover (Section 6.6) = supplied by vendor; tested for acceptable phosphorus index (P-Index) of between 10 and 30, OR Between 7 and 23 mg/kg of P in the soil media	
Sub-soil Testing (Section 6.2): not needed if an underdrain used; Min infiltration rate > 1/2 inch/hour in order to remove the underdrain requirement.	Sub-soil Testing (Section 6.2): one per 1,000 sq. ft. of filter surface; Min infiltration rate > 1/2 inch/hour in order to remove the underdrain requirement.
Underdrain (Section 6.7) = Schedule 40 PVC with clean-outs	Underdrain & Underground Storage Layer (Section 6.7) = Schedule 40 PVC with clean outs, and a minimum 12-inch stone sump below the invert; OR, none, if soil infiltration requirements are met (Section 6.2)
Inflow: sheetflow, curb cuts, trench drains, concentrated flow, or the equivalent	
Geometry (Section 6.3): Length of shortest flow path/Overall length = 0.3; OR, other design methods used to prevent short-circuiting; a one-cell design (not including the pre-treatment cell).	Geometry (Section 6.3): Length of shortest flow path/Overall length = 0.8; OR, other design methods used to prevent short-circuiting; a two-cell design (not including the pretreatment cell).
Pre-treatment (Section 6.4): a pretreatment cell, grass filter strip, gravel diaphragm, gravel flow spreader, or another approved (manufactured) pre-treatment structure.	Pre-treatment (Section 6.4): a pretreatment cell plus one of the following: a grass filter strip, gravel diaphragm, gravel flow spreader, or another approved (manufactured) pre-treatment structure.
Conveyance & Overflow (Section 6.5)	Conveyance & Overflow (Section 6.5)
Planting Plan (Section 6.8): a planting template to include turf, herbaceous vegetation, shrubs, and/or trees to achieve surface area coverage of at least 75% within 2 years.	Planting Plan (Section 6.8): a planting template to include turf, herbaceous vegetation, shrubs, and/or trees to achieve surface area coverage of at least 90% within 2 years. If using turf, must combine with other types of vegetation ¹ .
Building Setbacks³ (Section 5): 0 to 0.5 acre CDA = 10 feet if down-gradient from building or level (coastal plain); 50 feet if up-gradient. 0.5 to 2.5 acre CDA = 25 feet if down-gradient from building or level (coastal plain); 100 feet if up-gradient. (Refer to additional setback criteria in Section 5)	
Deeded Maintenance O&M Plan (Section 8)	
¹ Storage depth is the sum of the Void Ratio (Vr) of the soil media and gravel layers multiplied by their respective depths, plus the surface ponding depth. Refer to Section 6.1. ² A ponding depth of 6 inches is preferred. Ponding depths greater than 6 inches will require a specific planting plan to ensure appropriate plant selection (Section 6.8). ³ These are recommendations for simple building foundations. If an in-ground basement or other special conditions exist, the design should be reviewed by a licensed engineer. Also, a special footing or drainage design may be used to justify a reduction of the setbacks noted above.	





Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

Key Design Considerations: **Bioretention**

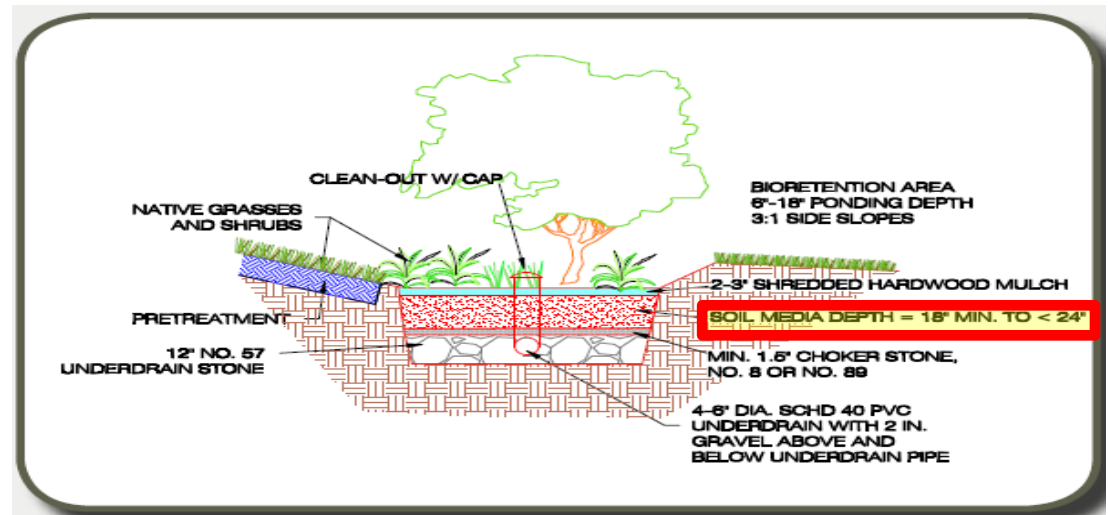
- Applications
- Sizing based on Tv_{BMP} (not simple surface area sizing based on % of CDA)

Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

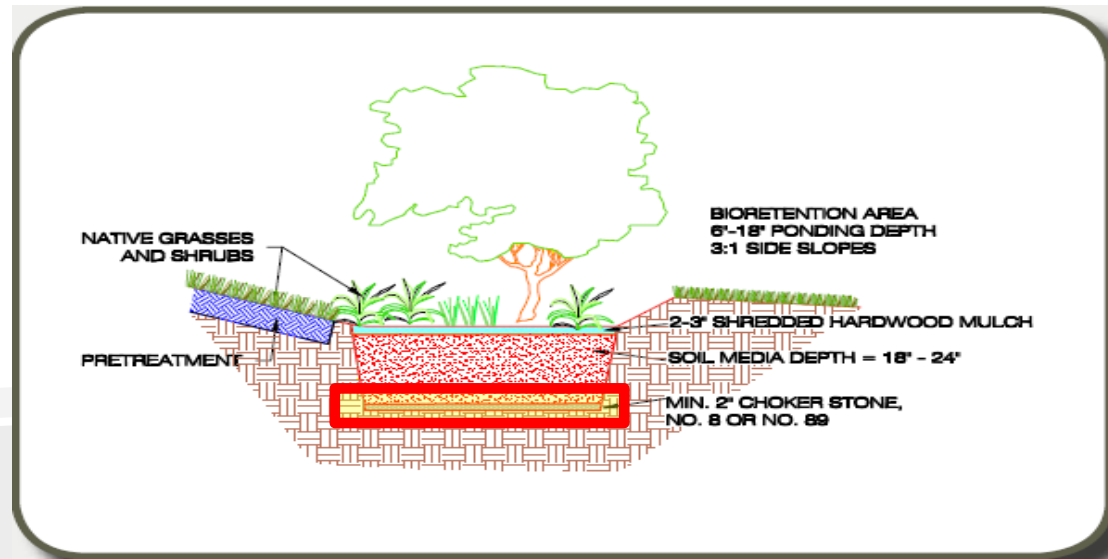
Level 1:

- Soil depth > 24"
- Underdrain
- Pretreatment



Level 2:

- Infiltration
- Soil depth > 36"
- Pretreatment (+)

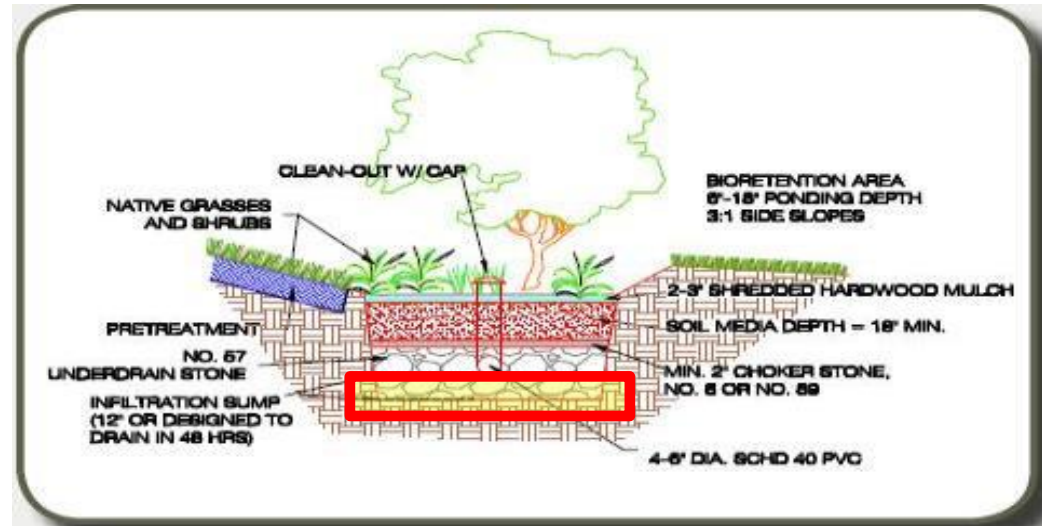


Bioretention

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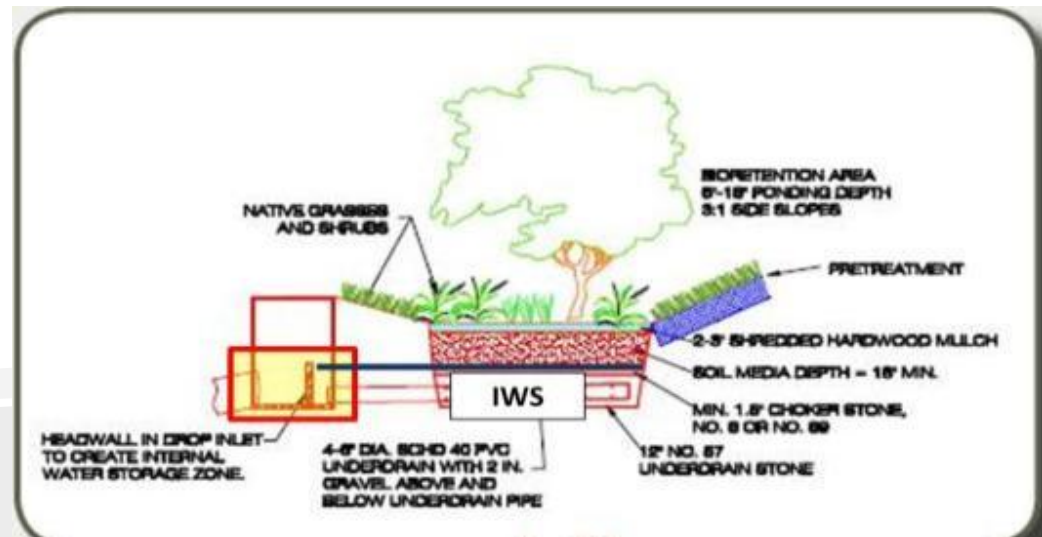
Level 2:

- Infiltration Sump



Level 2:

- Infiltration Sump with Internal Water Storage (IWS)





Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

Key Design Considerations: **Sizing**

Sizing of Bioretention based on capturing Tv_{BMP} within combined storage of surface ponding, soil media, and gravel (sump or under drain reservoir)

Accepted porosity (η) for each of materials is:

- Bioretention Soil Media $\eta = 0.25$
- Gravel $\eta = 0.40$
- Surface Storage $\eta = 1.0$



Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

Key Design Considerations: **Sizing**

Level 1: Equivalent storage depth for Level 1 with 6-inch surface ponding depth, 24-inch soil media depth, and 12-inch gravel layer computed as:

$$(2 \text{ ft.} \times 0.25) + (1 \text{ ft.} \times 0.40) + (0.5 \times 1.0) = 1.40 \text{ ft.}$$

Corresponding surface area (SA) computed as:

$$SA \text{ (sq. ft.)} = Tv_{BMP} / 1.40 \text{ ft.}$$

Where: Tv_{BMP} = Level 1 BMP design treatment volume (cu. ft.)

$$= [(1.0 \text{ in.})(R_v)(A) / 12]$$



Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

Key Design Considerations: **Sizing**

Level 2: Equivalent storage depth for Level 1 with 6-inch surface ponding depth, 24-inch soil media depth, and 12-inch gravel layer computed as:

$$(3 \text{ ft.} \times 0.25) + (1 \text{ ft.} \times 0.40) + (0.5 \times 1.0) = 1.65 \text{ ft.}$$

Corresponding surface area (SA) computed as:

$$SA \text{ (sq. ft.)} = Tv_{BMP} / 1.65 \text{ ft.}$$

Where: Tv_{BMP} = Level 1 BMP design treatment volume (cu. ft.)

$$= 1.25 [(1.0 \text{ in.})(R_v)(A) / 12];$$

Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

Key Design Consideration: **Surface Ponding**

- Limits on increasing area of surface storage



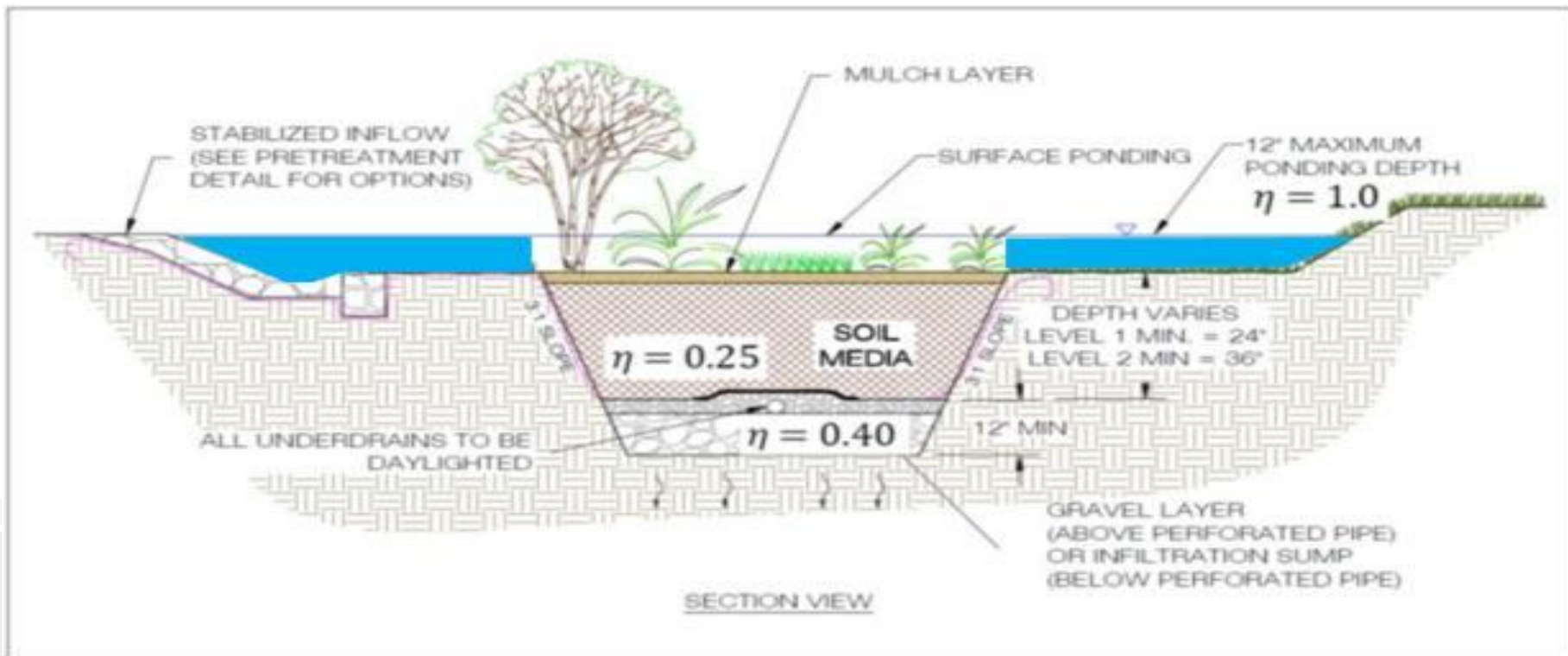
Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

Key Design Consideration: **Surface Ponding**

Limits on increasing area of surface storage

- $\leq 50\%$ increase if ponding is 6" or less
- $\leq 25\%$ increase if ponding is between 6 and 12"



Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

Key Design Consideration: Geometry & Flow Path



Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

Key Design Consideration: Inflow

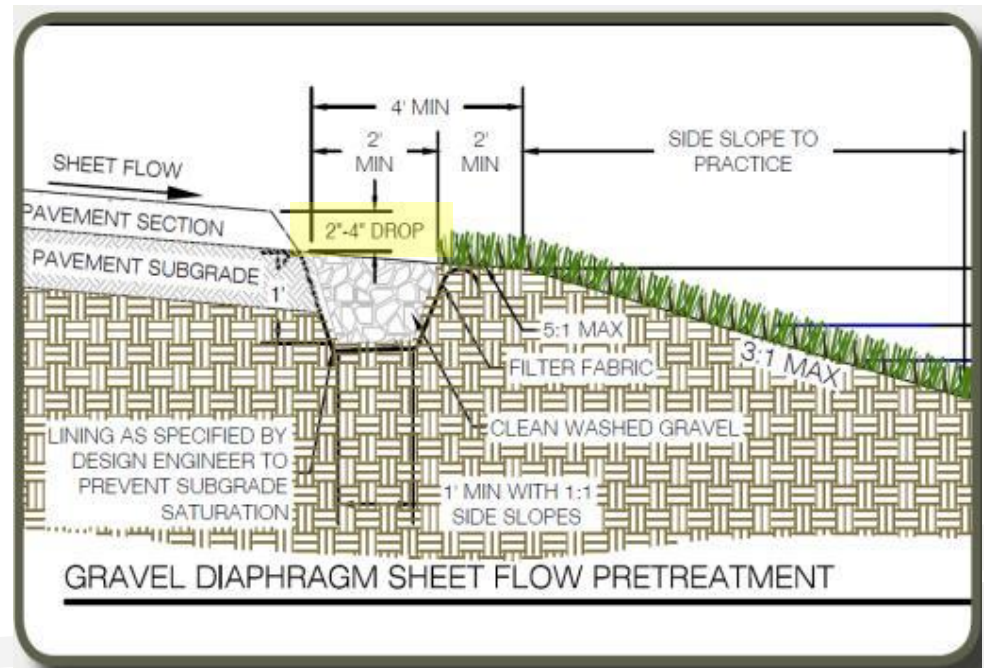


Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

Key Design Consideration: Pre-treatment

- Level 2: two pretreatment features required



Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

Key Design Consideration: Media Components

- Soil media
- Choker stone (no filter fabric!)
- Underdrains



Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

Key Design Consideration: Vegetation



Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

Urban Bioretention



Urban Planters



Expanded Tree Box



Curb Extensions

Bioretention

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 9

Urban-Bioretention Design Criteria

Level 1 Design Only (RR: 40; TP: 25)
Sizing (Refer to Section 9-A-6.1): Surface Area (sq. ft.) = $T_v/2 = \{[(1.0 \text{ inch})(R_v)(A)/12]\} + \text{any remaining volume from upstream BMP } \}/2$
Underdrain = Schedule 40 PVC with clean-outs (Refer to the Main Bioretention Design Specification, Section 6.7)
Maximum Drainage Area = 2,500 sq. ft.
Maximum Ponding Depth = 6 to 12 inches ¹
Filter media depth minimum = 30 inches; recommended maximum = 48 inches
Media and Surface Cover (Refer to the Main Bioretention Design Specification, Section 6.6)
Sub-soil testing (Refer to the Main Bioretention Design Specification, Section 6.2)
Inflow = <u>sheetflow</u> , curb cuts, trench drains, roof drains, concentrated flow, or equivalent
Building setbacks (Refer to Section A-4 9-A-5)
Deeded maintenance O&M plan (Refer to the Main Bioretention Design Specification, Section 9.1)
¹ Ponding depth above 6 inches will require a specific planting plan to ensure appropriate plants (Refer to the Main Bioretention Design Specification, Section 6.1).

Dry Swale

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 10



Wet Swale

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 11



Filtering Practices

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 12



Constructed Wetlands

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 13



Wet Ponds

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 14



Extended Detention Ponds

VIRGINIA DEQ STORMWATER DESIGN SPECIFICATION No. 15



Questions?

